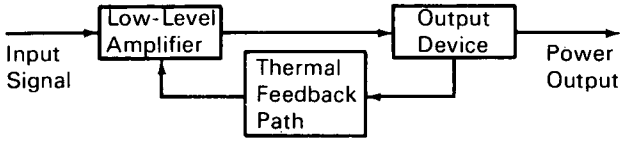
December 1970

Brief 70-10262

NASA TECH BRIEF

Power Semiconductor Device With Negative Thermal Feedback

Power semiconductors include power transistors, which are generally multi-emitter devices or parallel-connected multi-transistors. When used in power circuitry, one of the greatest drawbacks of transistors is the incidence of failure due to an inherent temperature instability called second breakdown. An increase in temperature at one region of the transistor leads to a disproportionate electric current flow through that region, which leads to a further increase in the temature of the region, until failure occurs; or an excess current in one emitter finger or region with accompanying temperature rise initiates the instability, and the cycle continues due to positive thermal feedback until all the current flows through the one region. A thermally unstable region or hot spot will be present even in ideal device structures. Second breakdown is most troublesome in the low current, high voltage operation range.



Schematic Representation of Heat Flow in the Power Semiconductor

A composite power semiconductor can be adapted to avoid second breakdown and provide stable operation. This semiconductor consists of an array of parallel-connected integrated circuits fabricated in a single chip. Each circuit has an output power device connected between an electric power source and a load and has one or more associated low-level control amplifiers. A block diagram shows the heat flow in the power semiconductor. The output power device and associated low-level amplifier are closely coupled thermally, so that both have substantially the same temperature at all times or have a predetermined temperature relationship. The two are interconnected in a fashion that will produce high electrical gain.

There is negative thermal feedback which controls the gain of the low-level amplifier in such a manner that when the temperature increases, the negative feedback also increases. This condition results in a decrease in the gain of the low-level amplifier and, in turn, in a decrease in the output power, since it is a function of the gain of the low-level amplifier. An increase in temperature, which tends to cause the output device and the low-level amplifier to conduct a larger amount of current, can maintain the output current substantially constant because of the close thermal coupling and interconnection.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Headquarters
National Aeronautics
and Space Administration
Washington, D.C. 20546
Reference: TSP70-10262

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. D. Thornton and J. M. Borky of
Massachusetts Institute of Technology
under contract to
NASA Headquarters
(HQN-10577)

Category 01